Transformer differential protection

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# Sepam 2000 D22 - D32
# Merlin Gerin

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# Selection table

*The Sepam 2000 D22 and D32 differential protections are designed to protect a two-ended or a three-ended zone which inckudes a transformer, an auto-transformer or a generator-transformer unit.*

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*Sepam 2000 D22*

## Advantages

- ■ Complete protection against internal transformer faults.
- ■ Restricted earth fault protection included.
- ■ Processing of transformer and neutral coil, Buchholz and thermostat data.
- ■ Simple implementation due to the use of neural networks:
  - □ simplified sizing of current sensors
  - □ few settings
  - □ no matching transformers required.
- ■ Measurement:
  - □ primary, secondary currents and phase shifts
  - □ residual currents
  - □ differential and through currents
  - □ memorization of differential and through current at the time of the fault.
- ■ Test position.
- ■ Disturbance recording.
- ■ High level of electromagnetic compatibility (EMC) makes it possible to use digital technology in electrical substations, without the need for any particular precautions.
- ■ **Sepam 2000's** continuous self-testing sets the device in a predetermined fail-safe position when failures occur, preventing random operation.
- ■ Terminal blocks which may be individually disconnected while energized to facilitate maintenance.
- ■ Setting and testing are extremely simple. The settings may be made on the front panel (serial link):
  - □ one by one, using the TSM2001 pocket terminal, or the SFT2801 PC software program
  - □ all at once using the SFT2821 PC software program (downloading).
- ■ The optional communication functions can be used for remote setting of protections, remote metering, remote annunciation and remote control via a two-wire link with a supervisor for centralized management.
- ■ ISO 9001 certified design and manufacturing processes.

## Selection table

| **Functions** | | **Sepam types** | |
|---|---|---|---|
| | | **D22** | **D32** |
| **Protections** | **ANSI code** | | |
| Biased differential | 87T | ■ | ■ |
| Restricted earth fault (winding 2) | 64REF | ■ | ■ |
| Restricted earth fault (winding 3) | 64REF | | ■ |
| **Metering** | | | |
| Phase currents I (winding 1) | | ■ | ■ |
| Phase currents I' (winding 2) | | ■ | ■ |
| Phase currents I'' (winding 3) | | | ■ |
| Phase shift between I and I' | | ■ | ■ |
| Phase shift between I and I'' | | | ■ |
| Residual current Io | | ■ | ■ |
| Residual current Io' | | ■ | ■ |
| Residual current Io'' | | | ■ |
| Differential currents: Id1, Id2, Id3 | | ■ | ■ |
| Through currents: It1, It2, It3 | | ■ | ■ |
| Tripping currents | differential: trip Id1, trip Id2, trip Id3 | ■ | ■ |
| | through: trip It1, trip It2, trip It3 | ■ | ■ |
| Disturbance recording | | ■ | ■ |
| **Control and monitoring** | | | |
| Latching/acknowledgment | 86 | ■ | ■ |
| Annunciation | 30 | ■ | ■ |
| Buchholz and thermostat | | ■ | |
| Auxiliary 1 | | ■ | |
| Auxiliary 2 | | ■ | |
| External tripping | | | ■ |
| Detection of plugged connector (DPC) | 74 | ■ | ■ |
| Fault trip counter | | ■ | ■ |
| Disturbance recording triggering | | ■ | ■ |
| **Sepam 2000 model** | | | |
| S36 | | CR | CC |
| Number of ESTOR boards | | 1 | 2 |

# Definitions and general parameters

## Définitions

The terms winding 1 and winding 2 are used like that:

- winding 1 refers to the circuit that has the highest voltage Un; the corresponding currents are connected to connectors 2A and 2B
- winding 2 refers to the circuit that has voltage Un' less than or equal to Un; the corresponding currents are connected to connectors 3A and 3B
- winding 3 refers to the circuit that has voltage Un'' less than or equal to Un'; the corresponding currents are connected to connectors 4A and 4B.

By extension, this definition also applies to an auto-transformer for which 2 windings are partially combined but which have different voltage level.

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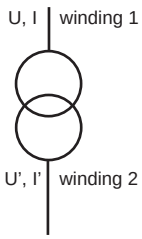


*Example of two-winding transformer: U= 66 kV, U'= 11 kV*

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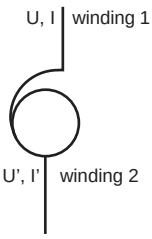


*Example of two-winding auto-transformer: U= 20 kV, U'= 15 kV*

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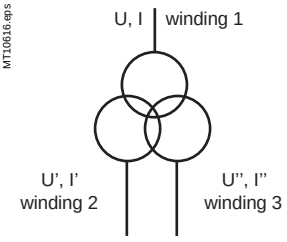
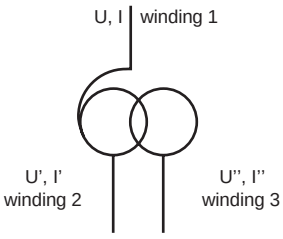



*Example of three-winding transformer: U = 132 kV, U' = 33 kV, U'' = 11 kV*




*Example of three-winding auto-transformer: U = 20 kV, U' = 15 kV, U'' = 6 kV*

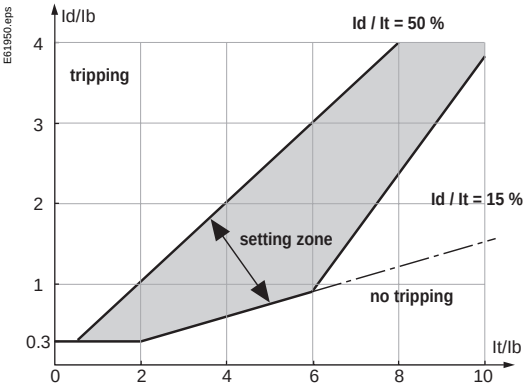
The zone protected by Sepam 2000 D22 is the zone between the current sensors connected to connectors 2A and 2B, at one end, and the sensors connected to connectors 3A and 3B at the other end.
The zone protected by Sepam 2000 D32 is the zone between the current sensors connected to connectors 2A and 2B at one end, and the sensors connected to connectors 3A, 3B, 4A and 4B at the other end.

## Status menu

| Parameters | Selection | Remote reading: function code and unit |
|---|---|---|
| Frequency Fn | 50 or 60 Hz | D5h - Hz |
| Phase CT ratio winding 1 In | 10 to 6250 A | D0h - A |
| Phase CT ratio winding 2 In' | 10 to 6250 A | D9h - A |
| Phase CT ratio winding 3 In'' (1) | 10 to 6250 A | DAh - A |
| Type of residual current sensor winding 1 | TC + CSH30 | D2h - index (4) |
| Rated residual current winding 1 Ino | 1 to 6250 A | D2h - A |
| Type of residual current sensor winding 2 | TC + CSH30 | DBh - index (4) |
| Rated residual current winding 2 Ino' | 1 to 6250 A | DBh - A |
| Type of residual current sensor winding 3 (1) | TC + CSH30 | DFh - index (4) |
| Rated residual current winding 3 Ino" (1) | 1 to 6250 A | DFh - A |
| Numerical index' of vector group (winding 2 versus winding 1) | 0 to 11 (2) | DEh |
| Numerical index" of vector group (winding 3 versus winding 1) | 0 to 11 (2) | DEh |
| Rated power of the transformer S (3) | 1 to 999 MVA | DEh - MVA |
| Rated voltage winding 1 Un | 220 V to 800 kV | DEh - V |
| Rated voltage winding 2 Un' | 220 V to 800 kV | DEh - V |
| Rated voltage winding 3 Un" | 220 V to 800 kV | DEh - V |

***(1)*** *Sepam 2000 D32.*
***(2)*** *Whatever the star or delta connections of the windings.*
***(3)*** *S refer to the rated power of the transformer in case of two-winding transformer. S refer to the winding of highest power in case of three-winding transformer.*
***(4)*** *Meaning of the index : 2 : TC + CSH30; other value : not used.*

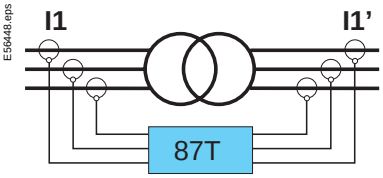
# Differential protection
## ANSI 87T code




*Percentage operation characteristics*

$\frac{S}{\sqrt{3}\ Un}$ = transformer rated current

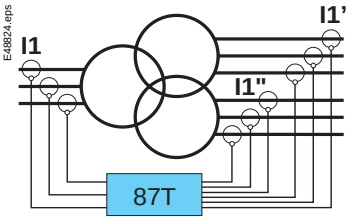
**Sepam 2000 D22:**




Id = $|\vec{I}_{adjusted} - \vec{I'}_{adjusted}|$ = differential current

It = max ( $|\vec{I}_{adjusted}|$, $|\vec{I'}_{adjusted}|$ ) = through current

**Sepam 2000 D32:**




Id = $|\vec{I}_{adjusted} - \vec{I'}_{adjusted} - \vec{I''}_{adjusted}|$ = differential current

It = max ( $|\vec{I}_{adjusted}|$, $|\vec{I'}_{adjusted}|$ , $|\vec{I''}_{adjusted}|$ )
= through current

## Operation

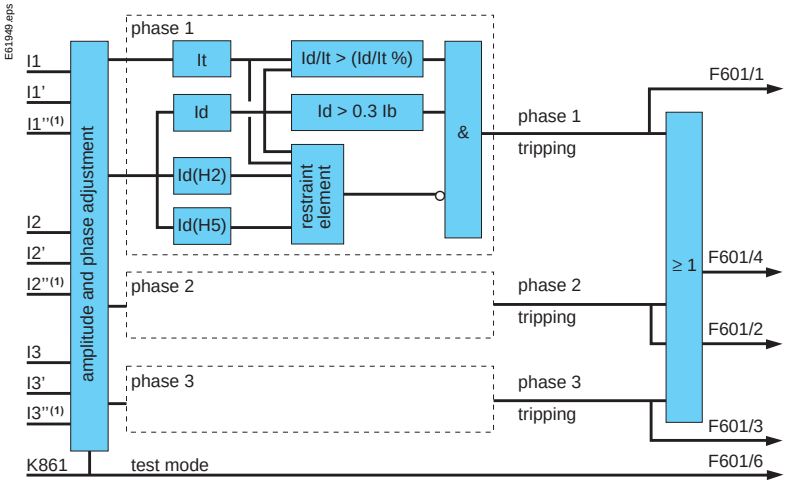
This protection adjusts the current phase and module of each winding according to the parameterized transformer connection. It then compares the adjusted currents, phase by phase. It is activated if the difference in currents Id for at least one phase is greater than the operation set point.

The set point is defined by the operation characteristic below.

Protection stability with respect to external faults is also ensured by the biased characteristic and by the 2nd and 5th harmonics neural network restraint which analyzes the percentage as well as the differential and through currents.

This restraint prevents unwanted tripping when:
- the transformer is switched on
- an asymmetrical fault occurs outside the zone, causing saturation of the current transformers
- the transformer is supplied by excessive voltage (overfluxing).

## Schematic diagram



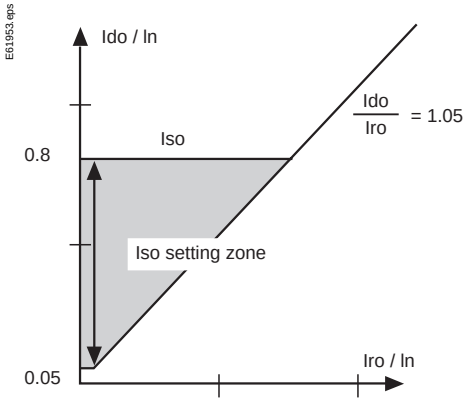

***(1)** D32 application*

## Characteristics

| | | |
|---|---|---|
| Function number | **F601** | |
| **Bias characteristic ID/It** | | |
| Setting | 15 to 50% | |
| Resolution | 1% | |
| Accuracy (1) | ±1% | |
| % drop-out | (86 ±10)% | |
| **Mini. setting** | | |
| Value | 0.3 Ib | |
| Accuracy (1) | ±5% | |
| % drop-out | (90 ±3)% | |
| **Time characteristics** | | |
| Operating time | < 35 ms | |
| Reset time | < 35 ms | |
| **Outputs available for control logic** | | |
| Phase 1 tripping | F601/1 | |
| Phase 2 tripping | F601/2 | |
| Phase 3 tripping | F601/3 | |
| Phase 1, 2 or 3 tripping | F601/4 | |
| Test mode | F601/6 | |
| **Remote reading, remote setting** | | |
| Function n° | 60 h | |
| Parameter | Id/It | unit: % |

***(1)** In reference conditions (IEC 60255-13).*

# Differential protection
## ANSI code 64 REF




*Operation characteristics*
*In: phase CT rating*

## Operation

Restricted earth fault protection detects phase-to-earth faults in a winding of a transformer, with an earthed neutral.
It offers the advantage of having greater sensitivity than differential protection.
The function is based on a comparison of the residual current Io ($\vec{Io} = \vec{I1} + \vec{I2} + \vec{I3}$) and the neutral current Ineutral.
It picks up if the module of the difference Io-Ineutral is greater than the operating set point. This set point is defined by, first, a minimum Iso set point and, secondly, by a percentage type tripping characteristic with a slope of 1.05 and an Ino restraint current characteristic in normal conditions (see curve).

$$Io = |\vec{I1} + \vec{I2} + \vec{I3}|$$

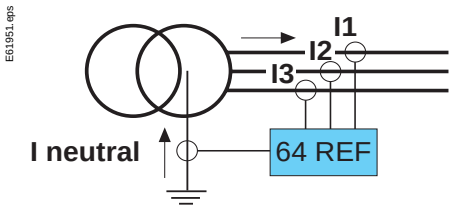
The sensitivity of the protection is determined by the phase current sensors with a minimum Iso set point of 5% In.
The protected zone is between the phase CTs and neutral CT.

## Stability with external faults

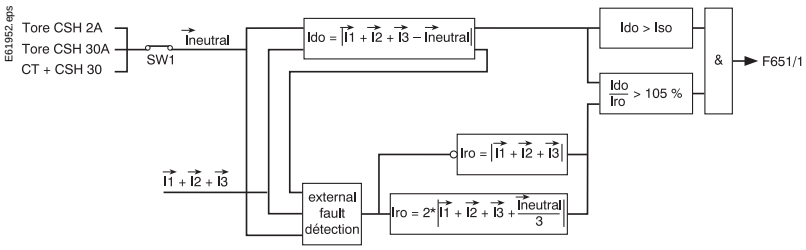
When an external fault is detected, the restraint current becomes equal to:

$$2 * |(\vec{I1} + \vec{I2} + \vec{I3}) + \vec{Io}/3|$$

This makes the protection insensitive to current transformer saturation without inhibiting its operation.




## Schematic diagram




## Characteristics

| | | |
|---|---|---|
| Function number | F651-F661 (2) | |
| **Iso setting** | | |
| Setting | 0.05 In to 0.8 In if In ≥ 20 A | |
| | 0.1 In to 0.8 In if In < 20 A | |
| Resolution | 1 A ou 1 digit | |
| Accuracy (1) | ±5% or ±0.5% In | |
| % drop-out | (93 ±5) % | |
| Min. reserve difference | min. 0.4% In | |
| **Biased characteristic Ido/Io** | | |
| Fixed value | 1.05 | |
| Accuracy (1) | ±2% | |
| **Time characteristics** | | |
| Operating time | < 40 ms | |
| Memory time | < 25 ms | |
| Fault recognition time | < 25 ms | |
| Reset time | < 40 ms | |
| **Outputs available for control logic** | | |
| Instantaneous tripping, 64 REF winding 2 | F651/1 | |
| Instantaneous tripping, 64 REF winding 3 (2) | F661/1 | |
| **Remote reading, remote setting** | | |
| Function code | F651 | 65h |
| | F661 (2) | 66h |
| Parameter | Threshold Iso | unit: 1A |

***(1)*** *In reference conditions (IEC 60255-13).*
***(2)*** *D32 application*

# Measurements

## Measurements used for commissioning and maintenance

Used to check current transformer connection and for testing.

**Phase current**
Measurement of current for each of the three phases of each winding.
Measurement of phase shift with respect to the primary current for each of the phases.

**Residual current**
Measurement of Io current for each winding.

**Differential and through current**
Display of the differential and through currents for each of the three phases, calculated by the differential protection, expressed in primary rms amps.

**Tripping currents**
Display of the value of the differential and through currents for each of the three phases, which was stored when the differential protection gave the tripping order, expressed in primary rms amps.

## Characteristics

| Measurements | Ranges | Accuracy (1) |
|---|---|---|
| Phase current | 0 to 24 In | ± 0.5% at In |
| Phase shift | 0 to 359° | ± 3° at In |
| Residual current Io | 0 to 10 Ino | ± 5% |
| Differential currents Id1, Id2, Id3 | 0 to 24 In | ± 5% |
| Through currents It1, It2, It3 | 0 to 24 In | ± 5% |
| Tripping currents:<br>Differential: trip Id1, trip Id2, trip Id3 | 0 to 24 In | ± 5% |
| Through: trip It1, trip It2, trip It3 | 0 to 24 In | ± 5% |

***(1)** in reference conditions (IEC 60255-13)*

The measurements are available directly in the appropriate units (A, kA) on Sepam via the console.

# Disturbance recording

## Operation

Used to record analog signal and logical states.

Record storage is triggered by a triggering event:
- tripping of differential protection
- tripping of restricted earth fault protection
- local manual triggering
- remote manual triggering.

The duration of the signal recorded before the triggering event may be set using the pocket terminal via the **oscillography** item in the **status** menu.

The date of record storage may also be accessed via the pocket terminal in the **oscillography** item of the **status** menu and via the communication link (refer to "Jbus/Modbus communication" document). This date corresponds to the date of the triggering event.
The stored event begins before the triggering event and continues afterwards.

The record includes of the following informations:
- values sampled from the different signals
- the date
- the characteristics of the recorded channels.

The files are recorded in FIFO (First In First Out) type shift storage: the oldest record is erased when a new record is triggered.

## Transfer

Files may be transferred locally or remotely:
- locally: using a PC which is connected to the console connector and has the SFT2801 software package (version later than 9802),
- remotely: using a software package specific to the remote monitoring and control system.

## Principe

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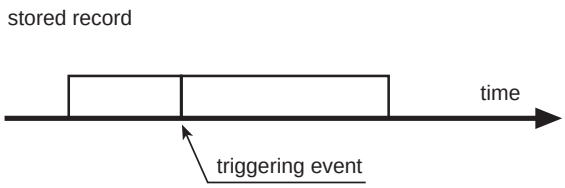


## Characteristics

| | |
|---|---|
| Record duration | 86 periods<br>the duration before the triggering event may be set from 1 to 85 periods. |
| Record content | set-up file: date and channel characteristics<br>data file: 12 values per period/recorded signal |
| Analog signals recorded | all currents connected to the acquisition boards |
| Logical states recorded | tripping outputs O1, O2 and O21,<br>differential and restricted earth fault operation<br>digital inputs, I11 to I18 |
| Number of records stored | 2 |
| File format | COMTRADE IEEE C37.111 - 1997<br>IEC 60255-24 |

## Restitution

Record signals may be restituted using the SFT2826 software program.

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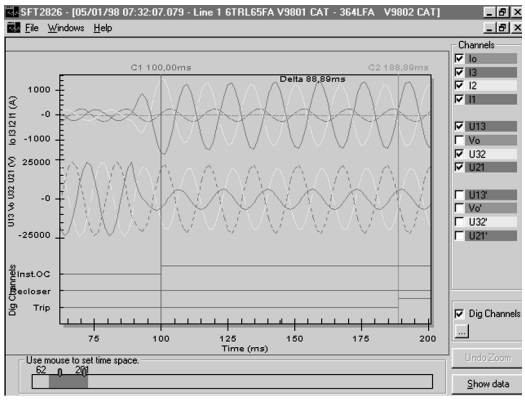


*Example of the processing of a disturbance recording record using the SFT2826 PC software program.*

# Control and monitoring

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## Latching / acknowledgment (ANSI 86)

Memorizes tripping orders (latching) and requires user action to be put back into service (reset).

## Annunciation (ANSI 30)

Informs the user by means of a message which appears on the display unit.

| Indications | Sepam 2000 D22 | Sepam 2000 D32 |
|---|---|---|
| **Alarms** | | |
| Buchholz | ■ | |
| Thermostat | ■ | |
| Auxiliary 1 | ■ | |
| Auxiliary 2 | ■ | |
| **Fault detection** | | |
| Differential | ■ | ■ |
| Secondary restricted earth fault | ■ | ■ |
| Tertiary restricted earth fault | | ■ |
| Buchholz | ■ | |
| Thermostat | ■ | |
| Auxiliary 1 | ■ | |
| Auxiliary 2 | ■ | |
| External tripping | | ■ |
| **Inhibition of differential protection** | | |
| Operating mode: test connection, inhibition of outputs | ■ | ■ |

## Detection of plugged connectors (DPC) (ANSI 74)

Indication on the display unit that one or more connectors are not plugged in (the DPC connections must be made: see connection diagrams).

## Buchholz and thermostat (D22 application)

Processes faults detected by the Buchholz and thermostat devices integrated in the equipment: alarm, tripping and indication.

## Auxiliary 1, auxiliary 2 (D22 application)

Processes faults detected by the auxiliary devices, such as Buchholz or thermostats or integrated in the on-load tap changer and neutral earthing: alarm, tripping and indication.

## External tripping (D32 application)

Input available to the Sepam to take into account a process fault detected by an other device: tripping an indication.

## Fault trip counter

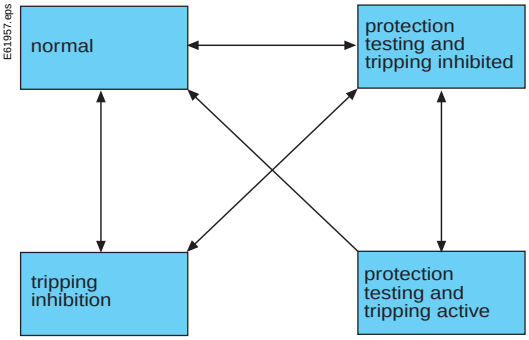
Counts the number of trips due to faults detected by the protections or other devices (Buchholz, auxiliary 1, auxiliary 2) to facilitate equipment maintenance.

## Disturbance recorder triggering

Triggers the recording of electrical signals and logical states:
- manualy by local or remote action
- automatically by differential and restricted earth fault protections functions.

Triggering may be locked in order to transfer disturbance records from Sepam 2000 to a PC.
Recording is unlocked by reactivating automatic or manual triggering.

# Operating mode




**Several operating modes are available to facilitate maintenance and commissioning operations.**

The change from one mode to the other is obtained by means of KP6 and KP9 parameter settings (1).

## Normal

The protection functions operate on tripping and signalling contacts according to the settings.
This mode is the normal operation mode.

## Tripping inhibition

The protection functions operate on signalling contacts according to the settings.
The tripping output contacts are inhibited.
This mode is designed to test Sepam 2000 when the protected equipment is still on duty.

## Test mode and tripping inhibited

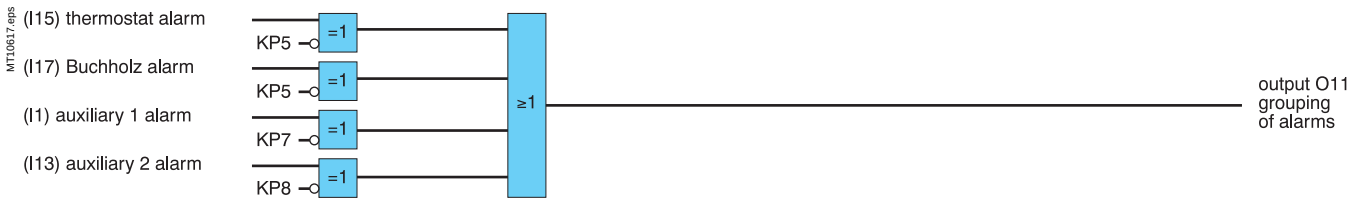
The protection functions operate on signalling contacts according to the "test mode settings" (1).
The tripping contacts are inhibited.
This mode is designed to facilate the test of Sepam when the protected equipment is still on duty.

## Test mode and tripping active

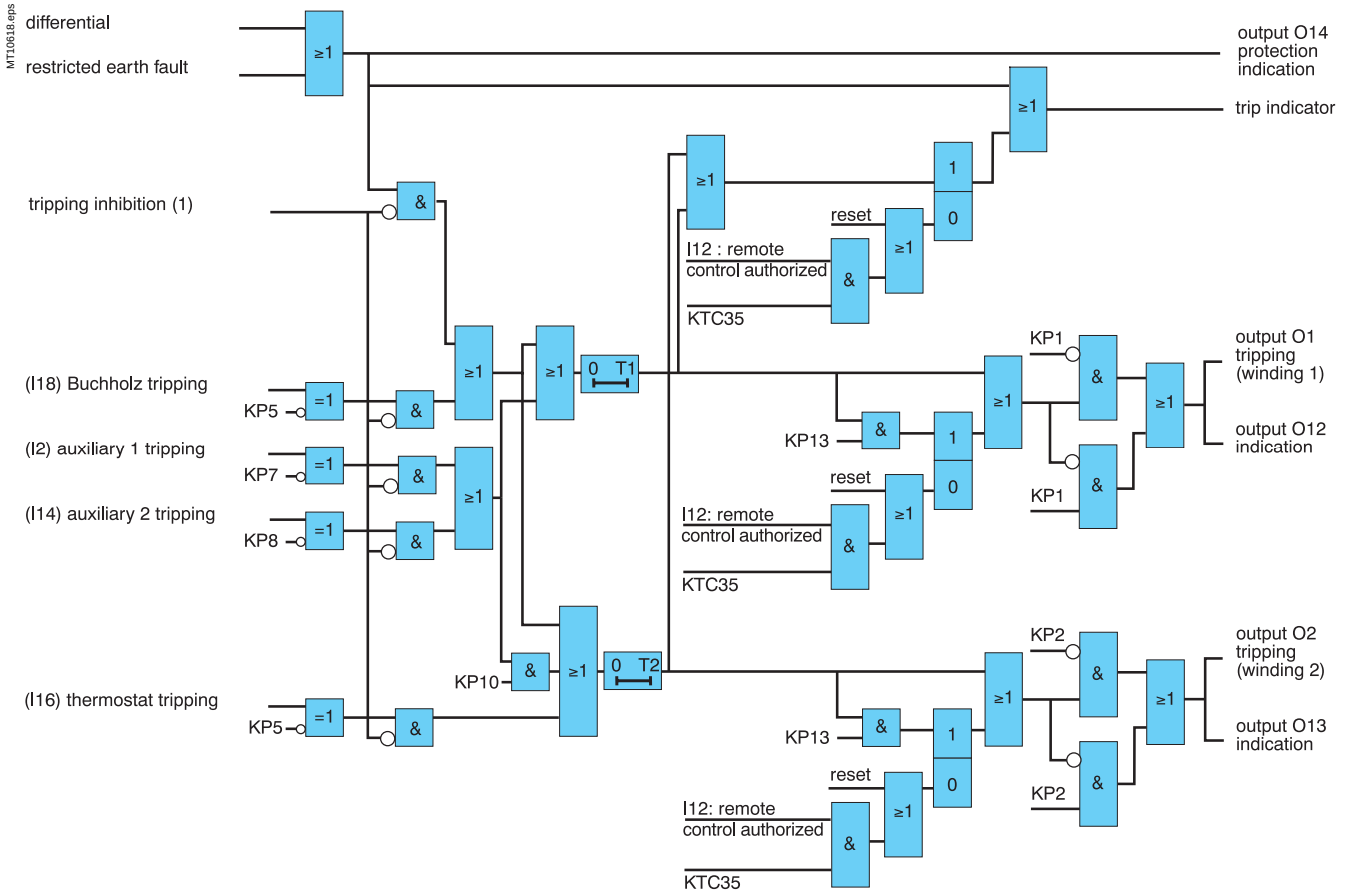
The protection functions operate on tripping and signalling contacts according to the "test mode settings" (1).
This mode is designed to facilate the test of Sepam 2000 including actuators and wiring. The protected equipment is not on duty.

*(**1**) See "Installation and user's manual".*

## Grouping of alarms




## Breaking devices tripping




***(1)*** *Tripping inhibition by test mode or by KP setting*

Outputs O1 and O2 are dedicated to the tripping of transformer windings 1 and 2 breaking devices.

Outputs O12 and O13 are dedicated to tripping indication.
Time delay T1 is used to calibrate the minimum operating duration of outputs O1 and O12 associated with winding 1 tripping.
Time delay T2 is used to calibrate the minimum operating duration of outputs O2 and O13 associated with winding 2 tripping.

Parameter KP13 = 1 latches outputs O1 - O2 - O12 - O13.
Acknowledgment is carried out by pressing “reset”. Output O11 is dedicated to alarms. It is not a latching relay. Output O14 is dedicated to transformer differential function indication. It is not a latching relay.

Input I18, associated with the Buchholz device, triggers windings 1 and 2 tripping.
Input I16, associated with the thermostat device, triggers winding 2 tripping.

Parameter KP10 affects winding 2 tripping logic via inputs I2 and I14 associated with the auxiliary 1 and auxiliary 2 devices:
- winding 1 tripping if KP10 = 0
- windings 1 and 2 tripping if KP10 = 1.

The "trip" indicator needs to be reset, whatever the parameter setting.

## Operation

| Functions | Control | | Indication | | | | |
|---|---|---|---|---|---|---|---|
| | O1 winding 1 | O2 winding 2 | O11 | O12 | O13 | O14 | Message |
| Differential | ■ | ■ | | ■ | ■ | ■ | DIFF. |
| Restricted earth fault | ■ | ■ | | ■ | ■ | ■ | REF |
| Buchholz alarm | | | ■ | | | | BUCHHOLZ |
| Buchholz tripping | ■ | ■ | | ■ | ■ | | BUCHHOLZ |
| Thermostat alarm | | | ■ | | | | TR.TEMP |
| Thermostat tripping | ■ (1) | ■ | | | ■ | | TR.TEMP |
| Auxiliary 1 alarm | | | ■ | | | | AUX .1 |
| Auxiliary 1 tripping | ■ | ■ (1) | | ■ | ■ (1) | | AUX .1 |
| Auxiliary 2 alarm | | | ■ | | | | AUX .2 |
| Auxiliary 2 tripping | ■ | ■ (1) | | ■ | ■ (1) | | AUX .2 |
| Detection of plugged connectors | | | | | | | CONNECTOR |

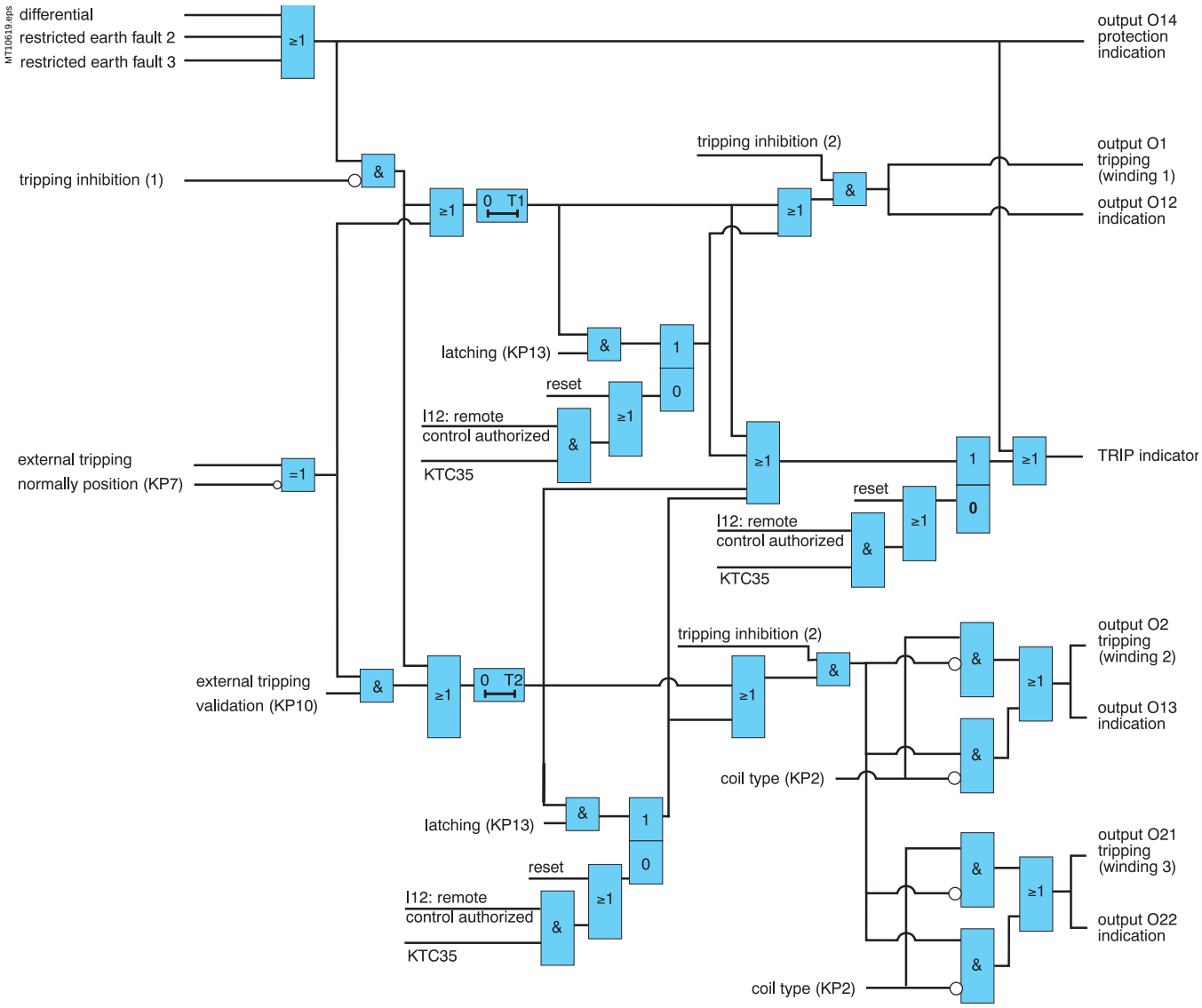
***(1)*** *According to parameter setting.*

## Parameter setting

Parameters KP can be set by means of the console

| Functions | | Parameter |
|---|---|---|
| **Tripping control** | | |
| Winding 1 with shunt trip coil | | KP1 = 0 |
| Winding 1 with undervoltage release coil | | KP1 = 1 |
| Winding 2 with shunt trip coil | | KP2 = 0 |
| Winding 2 with undervoltage release coil | | KP2 = 1 |
| **Operating functions** | | |
| Inputs I15 - I16 - I17 - I18 activated | normally closed contact | KP5 = 0 |
| if fault detected by Buchholz / thermostat devices | normally open contact | KP5 = 1 |
| Inputs I1 - I2 activated | normally closed contact | KP7 = 0 |
| if fault detected by auxiliary 1 device | normally open contact | KP7 = 1 |
| Inputs I13 - I14 activated | normally closed contact | KP8 = 0 |
| if fault detected by auxiliary 2 device | normally open contact | KP8 = 1 |
| Aux. 1 (I2) and Aux. 2 (I14) activate winding 1 (upstream) tripping | | KP10 = 0 |
| Aux. 1 (I2) and Aux. 2 (I14) activate windings 1 and 2 tripping | | KP10 = 1 |
| Latching of outputs associated with tripping O1 - O2 - O12 - O13 | | KP13 = 1 |
| **Operating mode** | | |
| Switching to test mode | | KP6 = 1 |
| Inhibition of differential and restricted earth fault tripping | | KP9 = 1 |
| **Counter** | | |
| Resetting of fault trip counter | | KP20 = 1 |
| **Disturbance recording** | | |
| Lock triggering | | KP50 = 1 |
| Automatic unlock and triggering | | KP51 = 1 |
| Manual unlock and triggering | | KP52 = 1 |
| **Remote setting** | | |
| Remote setting enable | | KP38 = 0 |
| Remote setting disable | | KP38 = 1 |

## Breaking devices tripping




***(1)*** *Tripping inhibition by test mode or by KP setting*
***(2)*** *Tripping inhibition as the former one, but held during 2 Sepam cycles after the end of the tripping inhibition setting (see "Installation and user's manual").*

Outputs O1, O2 and O21 are dedicated to the tripping of transformer windings 1, 2 and 3 breaking devices.
Outputs O12, O13 and O22 are dedicated to tripping indication.

Time delay T1 is used to calibrate the minimum operating duration of outputs O1 and O12 associated with winding 1 tripping.
Time delay T2 is used to calibrate the minimum operating duration of outputs O2, O13, O21 and O22 associated with windings 2 and 3 tripping.
Acknowledgment is carried out by pressing "reset".
Output O14 is dedicated to transformer differential function indication. It is not a latching relay.

Parameter KP10 affects windings 2 and 3 tripping logic via input I2 associated with the external tripping signal.
- Winding 1 tripping if KP10 = 0.
- Windings 1,2 and 3 tripping if KP10 = 1.

The "TRIP" indicator needs to be reset, whatever the parameter setting.

***Nota :***
- *the operating of the winding 2 it the same as the operating of the winding 3 (if one trips, the other does it too)*
- *the winding 1 breaking device is with shunt trip coil. The windings 2 and 3 breaking devices may be setted with shunt trip coil or with undervoltage release coil.*

## Operation

| Functions | Control | | Indication | | | | | |
|---|---|---|---|---|---|---|---|---|
| | O1 winding 1 | O2 winding 2 | O21 winding 3 | O12 winding 1 | O13 winding 2 | O14 | O22 winding 3 | Message |
| Differential | ■ | ■ | ■ | ■ | ■ | ■ | ■ | DIFF. |
| Restricted earth fault winding 2 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | REF 2 |
| Restricted earth fault winding 3 | ■ | ■ | ■ | ■ | ■ | ■ | ■ | REF 3 |
| External tripping | ■ | □ (1) | □ (1) | ■ | □ (1) | | □ (1) | EXT. TRIP. |
| Detection of plugged connectors | | | | | | | | CONNECTOR |

***(1)*** *According to parameter setting.*

## Parameter setting

Parameters KP can be set by means of the console

| Functions | | Parameter |
|---|---|---|
| **Tripping control** | | |
| Winding 2 with shunt trip coil | | KP2 = 0 |
| Winding 2 with undervoltage release coil | | KP2 = 1 |
| Winding 3 with shunt trip coil | | KP3 = 0 |
| Winding 3 with undervoltage release coil | | KP3 = 1 |
| **Operating functions** | | |
| Input I2 activated if fault detected by auxiliary device (external tripping) | normally closed contact | KP7 = 0 |
| | normally open contact | KP7 = 1 |
| External tripping (I2) activates winding 1 (upstream) tripping | | KP10 = 0 |
| External tripping (I2) activates windings 1, 2 and 3 tripping | | KP10 = 1 |
| Latching of outputs associated with tripping O1 - O2 - O12 - O13 - O21 - O22 | | KP13 = 1 |
| **Operating mode** | | |
| Switching to test mode | | KP6 = 1 |
| Inhibition of differential and restricted earth fault tripping | | KP9 = 1 |
| **Counter** | | |
| Resetting of fault trip counter | | KP20 = 1 |
| **Disturbance recording** | | |
| Lock triggering | | KP50 = 1 |
| Automatic unlock and triggering | | KP51 = 1 |
| Manual unlock and triggering | | KP52 = 1 |
| **Remote setting** | | |
| Remote setting enable | | KP38 = 0 |
| Remote setting disable | | KP38 = 1 |

# Modbus communication

## Introduction

The communication option can be used to connect Sepam 2000 to a remote monitoring and control system equipped with a communication channel.
Sepam can be equipped with the Jbus/Modbus communication option. It is a master-slave protocol with RS485 and with 2-wire physical link
(300 to 38400 baud rate).

## Remote reading of settings

The Jbus/Modbus communication option can be used for remote reading of the following information:
- general characteristics
- protection settings
- status and settings of all control logic resources.

## Remote setting

The Jbus/Modbus communication option can be used for remote modification of the following parameters:
- protection settings
- control logic time delay set points.

## Time-tagging

The communication option can be used for accurate dating of all remote indications (1).

***(1)** See "Jbus/Modbus communication" manual, article 75757*

## List of available data

| **Remote indications** | **Adresses** |
|---|---|
| Logic input status | |
| Logic output status | |
| Fault trip counter | C2 |
| Sepam not reset (after fault) | KTS5 |
| Remote control validation report | KTS14 |
| Differential | KTS15 |
| Buccholz alarm | KTS17 (1) |
| Buchholz tripping | KTS18 (1) |
| Thermostat alarm | KTS19 (1) |
| Thermostat tripping | KTS20 (1) |
| Auxiliary 1 alarm | KTS21 (1) |
| Auxiliary 1 tripping | KTS22 (1) |
| External tripping | KTS22 (2) |
| Auxiliary 2 alarm | KTS23 (1) |
| Auxiliary 2 tripping | KTS24 (1) |
| Restricted earth fault winding 2 | KTS25 |
| Restricted earth fault winding 3 | KTS26 (2) |
| Inhibition | KTS30 |
| Test | KTS31 |
| Inhibited disturbance recording (lock triggering) | KTS50 |
| Remote setting inhibited | KTS51 |
| **Remote control orders** | **label** |
| Acknowledgment of messages | KTC35 |
| Inhibition disturbance recording lock triggering | KTC50 |
| Automatic unlock and triggering of disturbance recording | KTC51 |
| Manual unlock and triggering of disturbance recording | KTC52 |
| **Remote reading - remote setting** | |
| Parameters (reading only) | |
| Protections settings | |
| Control delay settings | |

***(1)** D22 application*
***(2)** D32 application*

# General characteristics

## Electrical characteristics

| | | | | | |
|---|---|---|---|---|---|
| **Analog inputs** | | | | | |
| Current transformer | | 1 A CT | < 0.001 VA | | |
| 10 A to 6250 A ratings | | 5 A CT | < 0.025 VA | | |
| **Logic inputs** | | | | | |
| Voltage | | 24/30 Vdc | 48/127 Vdc | 220/250 Vdc | |
| Consumption | | 4 mA | 4 mA | 3 mA | |
| **Auxiliary power supply** | | | | | |
| DC voltage | | 24/30 Vdc | 48/127 Vdc | 220/250 Vdc | |
| Typical consumption | | 18 W | 19.5 W | 21 W | |
| **ILgic outputs (relays)** | | | | | |
| Voltage | | 24/30 Vdc | 48 Vdc | 125 Vdc | 220/250 Vdc |
| Rated current | | 8 A | 8 A | 8 A | 8 A |
| 400 ms overload | | 15 A | 15 A | 15 A | 15 A |
| Making capacity | | 15 A | 15 A | 15 A | 15 A |
| Breaking capacity: | DC with resistive load | 8 A | 4 A | 0.8 A | 0.3 A |
| | DC with resistive load | 6 A | 2 A | 0.4 A | 0.15 A |
| | DC at L/R = 40 ms | 4 A | 1 A | 0.2 A | 0.1 A |
| | AC with resistive load | 8 A | 8 A | 8 A | 8 A |
| | AC with p.f. = 0.3 | 5 A | 5 A | 5 A | 5 A |

## Environmental characteristics

| | | | |
|---|---|---|---|
| **Electric insulation** | | | |
| Dielectric withstand | IEC 60255-5 | 2 kV - 1 mn (1) | |
| 1.2/50 µs impulse wave withstand | IEC 60255-5 | 5 kV (2) | |
| **Climatic withstand** | | | |
| Operation | IEC 60068-2-1 and 2 | - 5 °C to + 55 °C | |
| | IEC 60068-2-14 | - 5 °C to + 55 °C | |
| Storage | IEC 60068-2 | - 25 °C to + 70 °C | |
| Damp heat | IEC 60068-2-3 | 93% RH at 40 °C<br>56 days (storage)<br>10 days (operation) | |
| Corrosion influence | IEC 60654-4 | class I | |
| **Mechanical robustness** | | | |
| Degree of protection | IEC 60529 | IP 51 | front face |
| Vibrations | IEC 60255-21-1 | class I | |
| Shocks / jolts | IEC 60255-21-2 | class I | |
| Earthquakes | IEC 60255-21-3 | class I | |
| Fire resistance | IEC 60695-2-1 | | glow wire |
| **Electromagnetic compatibility** | | | |
| Radiated fields | IEC 60255-22-3 | class X | 30 V/m |
| | IEC 61000-4-3 | class III | 10 V/m |
| Electrostatic discharge | IEC 60255-22-2 | class III | |
| | IEC 61000-4-2 | class III | |
| Damped 1 MHz wave | IEC 60255-22-1 | class III | |
| 5 ns electrical fast transients/burst | IEC 60255-22-4 | class IV | |
| | IEC 61000-4-4 | class IV | |
| 1.2/50ms - 8/20ms surge immunity | IEC 61000-4-5 | class III | 2 kV differential mode (42 Ω) |
| | | | 1 kV common mode (42 Ω) |
| Conducted disturbance emission | EN 55022/CISPR22 | class B | with auxiliary power supply (3) |
| Radiated field emission | EN 55022/CISPR22 | class B | (4) |

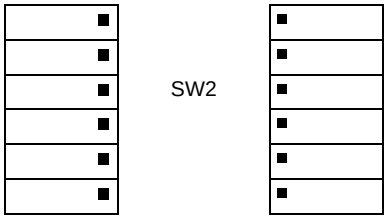
*"CE" marking on our product guarantees their conformity to European directives.*
*(**1**) except for communication 1.4 kV dc and auxiliary power supply 2.8 kV dc.*
*(**2**) except for communication 3 kV common mode, 1 kV differential mode.*
*(**3**) EN 50081-1 generic standard.*
*(**4**) EN 50081-2 generic standard.*

# Determination of current sensors and settings

## Implementation, settings

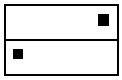
**Check:**
- ■ connections
- ■ settings of microswitches SW1 and SW2:
- □ measurement of phase currents

*1 A secondary* *5 A secondary*




□ measurement of Io current

*TC + CSH30*



For each transformer winding:
- ■ set SW1 to "CT + CSH30".

Set the following using the console:
- ■ general parameters
- ■ control logic parameters
- ■ differential protection percentage set point,

(set a value greater than the amplitude of on-load tap changer variation).
The 999% setting may be used to inhibit the protection all the outputs are set to zero.
- ■ The Iso setting of the restricted earth fault protection.

The 999 % setting may be used to inhibit the protection. All outputs are set to zero.

## Determination of current sensors

**For transformer differential protection**
- ■ The current transformers (CT) used shall be of the 5P20 type.
- ■ The phase CT rating should comply with the following rules:

$$0.1 \cdot \frac{S}{\sqrt{3}\ Un} \leqslant In \leqslant 2.5 \cdot \frac{S}{\sqrt{3}\ Un} \quad \text{for winding 1}$$

$$0.1 \cdot \frac{S}{\sqrt{3}\ Un'} \leqslant In' \leqslant 2.5 \cdot \frac{S}{\sqrt{3}\ Un'} \quad \text{for winding 2}$$

$$0.1 \cdot \frac{S}{\sqrt{3}\ Un''} \leqslant In'' \leqslant 2.5 \cdot \frac{S}{\sqrt{3}\ Un''} \quad \text{for winding 3}$$

"S" is the transformer power set in the status menu.
2 winding transformer: S is the rated power.
3 winding transformer: S is power value of the most powerful winding.
In, In' and In'' are the ratings of the winding 1, 2 and 3 phase current transformers respectively.
Un, Un' and Un'' are the winding 1, 2 and 3 voltages respectively.

**For restricted earth fault protection**
- ■ Stability with external faults is ensured if the phase CT saturation current is greater than 2.4 times the phase-to-earth fault current and 1.6 times the 3-phase fault current.

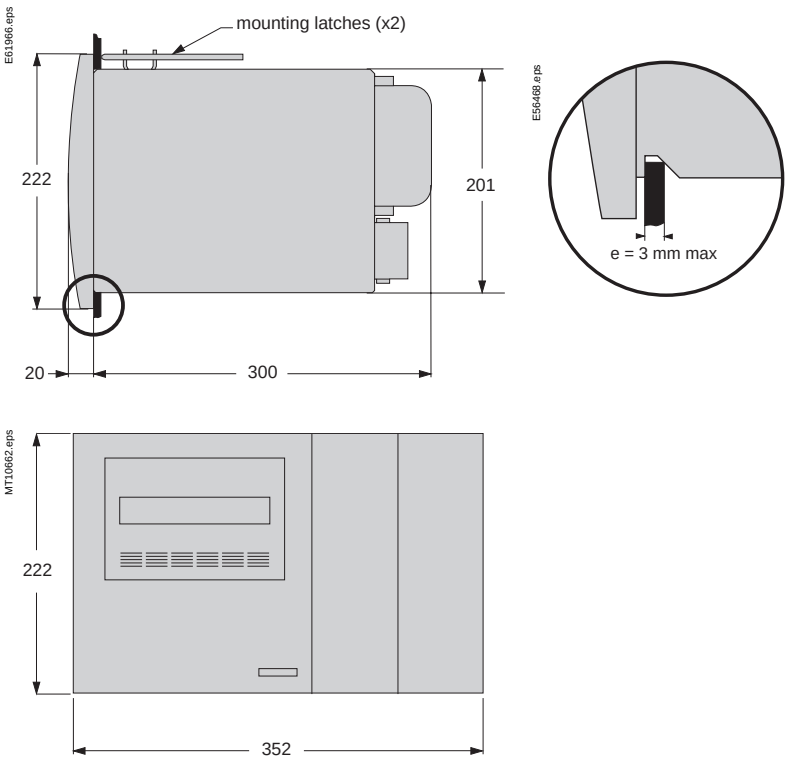
Sensitivity to internal faults is ensured if the neutral CT saturation current is greater than twice the phase-to-earth fault current.
- ■ The neutral point CT rating should comply with the following rule:

**0.1 In ⩽ neutral point CT rating ⩽ 2 In**
with In = phase CT rating of the same transformer winding.

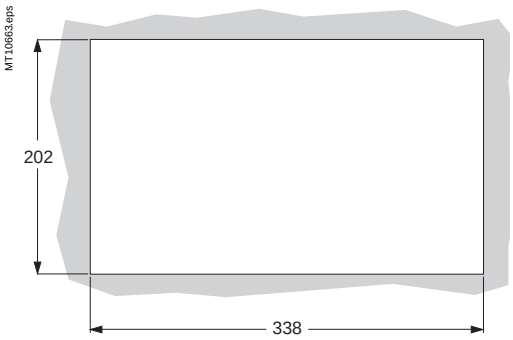
If the phase CT rated current In is sufficiently low (In ⩽ 300 A), the neutral current may be measured by a CSH120 or CSH200 core balance CT.
If this is not the case (which happens most frequently), the neutral current is measured by a CT. A CSH30 interposing ring CT is required between the 1 A or 5 A secondary winding of the neutral CT and the Sepam 2000 residual current input.

# Dimensions and weights
# Connections

## Dimensions and weights



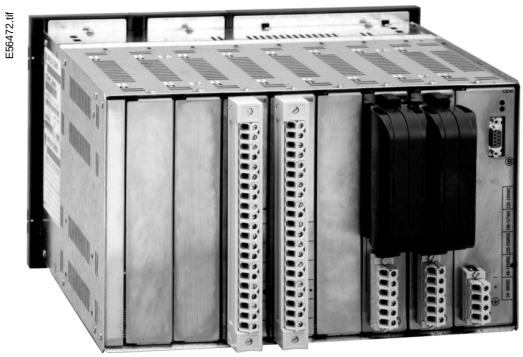

### Cut-out




## Connections

| | Type | Wiring / cabling | Accessories reference | Type |
|---|---|---|---|---|
| Current transformers | screw for ∅4 eye lug | ⩽ 6 mm² | CCA660 (1) | connector |
| CSH core balance CTs, CSH 30 adapter | screw | ⩽ 2.5 mm² | CCA606 (1) | connector |
| Logic inputs/outputs | screw | ⩽ 2.5 mm² | CCA621 (1) | connector |
| Power supply | screw | ⩽ 2.5 mm² | CCA604 (1) | connector |
| Jbus/Modbus communication | 9-pin sub-D connector | | CCA602 | cable (length: 3 m) with two 9-pin sub-D |
| | | | CCA619 | 9-pin sub-D connector box |

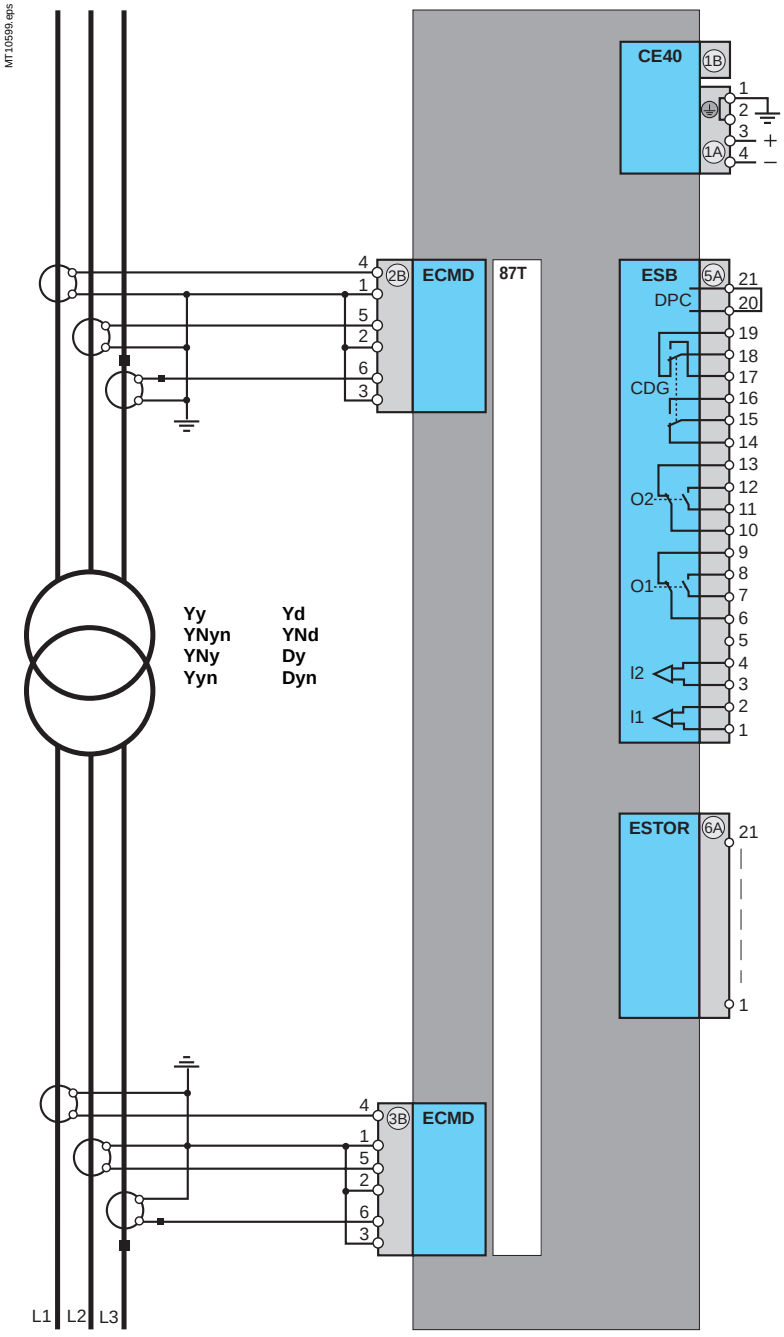
***(1)*** *Accessories supplied with Sepam 2000*




*Sepam 2000 D22 rear face with standard connectors*

# Two-winding transformer

The transformer neutral points may or may not be earthed.
No neutral point CT is necessary for proper operation of the differential protection.

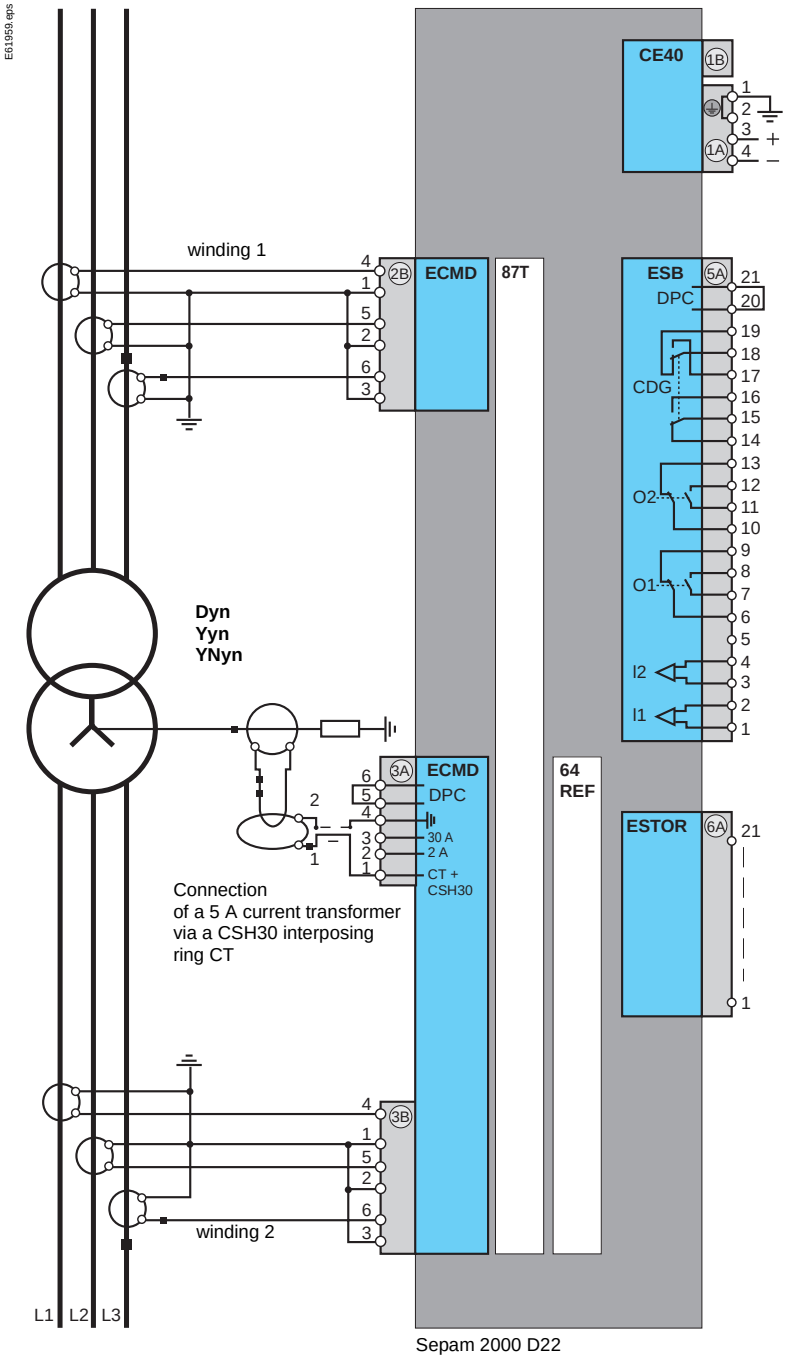



*DPC: detection of plugged connectors.*
*CDG: watchdog.*

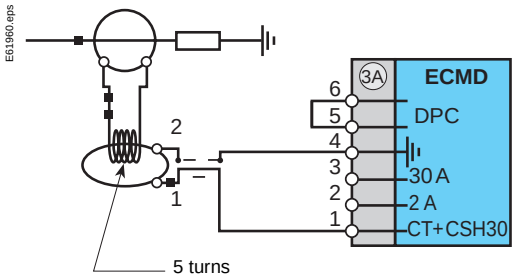
*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Two-winding transformer with earthed neutral point

The transformer primary neutral may or may not be earthed.
Neutral current measurement on the secondary winding is essential for correct operation of the restricted earth fault protection function.




Connection of a 1 A current transformer via a CSH30 interposing ring CT.

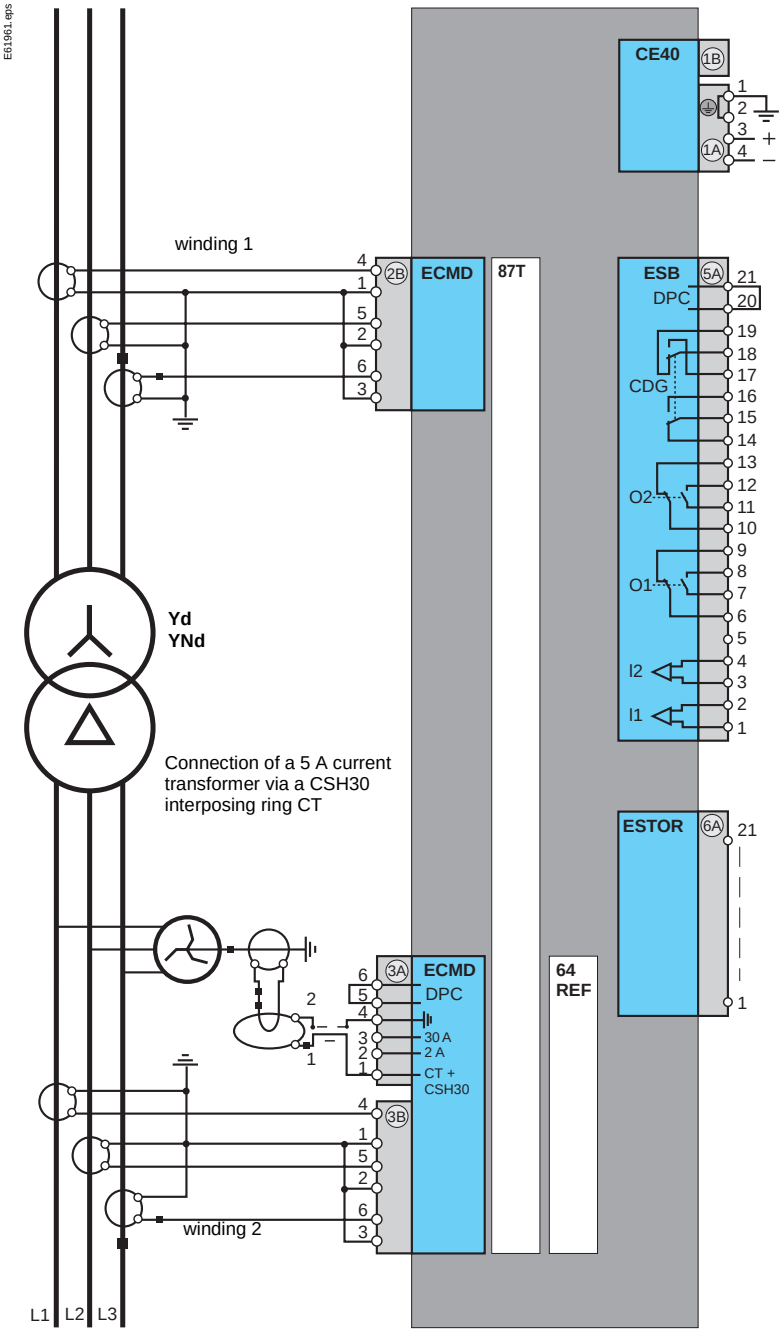



*DPC: detection of plugged connectors*
*CDG: watchdog*

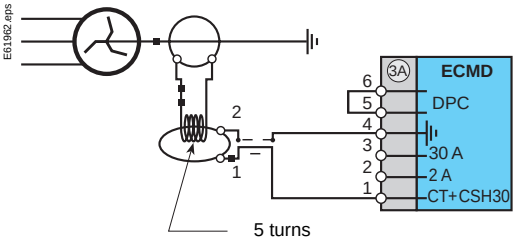
*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Two-winding transformer with earthing coil

The transformer primary neutral may or may not be earthed.
Neutral current measurement on the secondary winding is essential for correct operation of the restricted earth fault protection function.



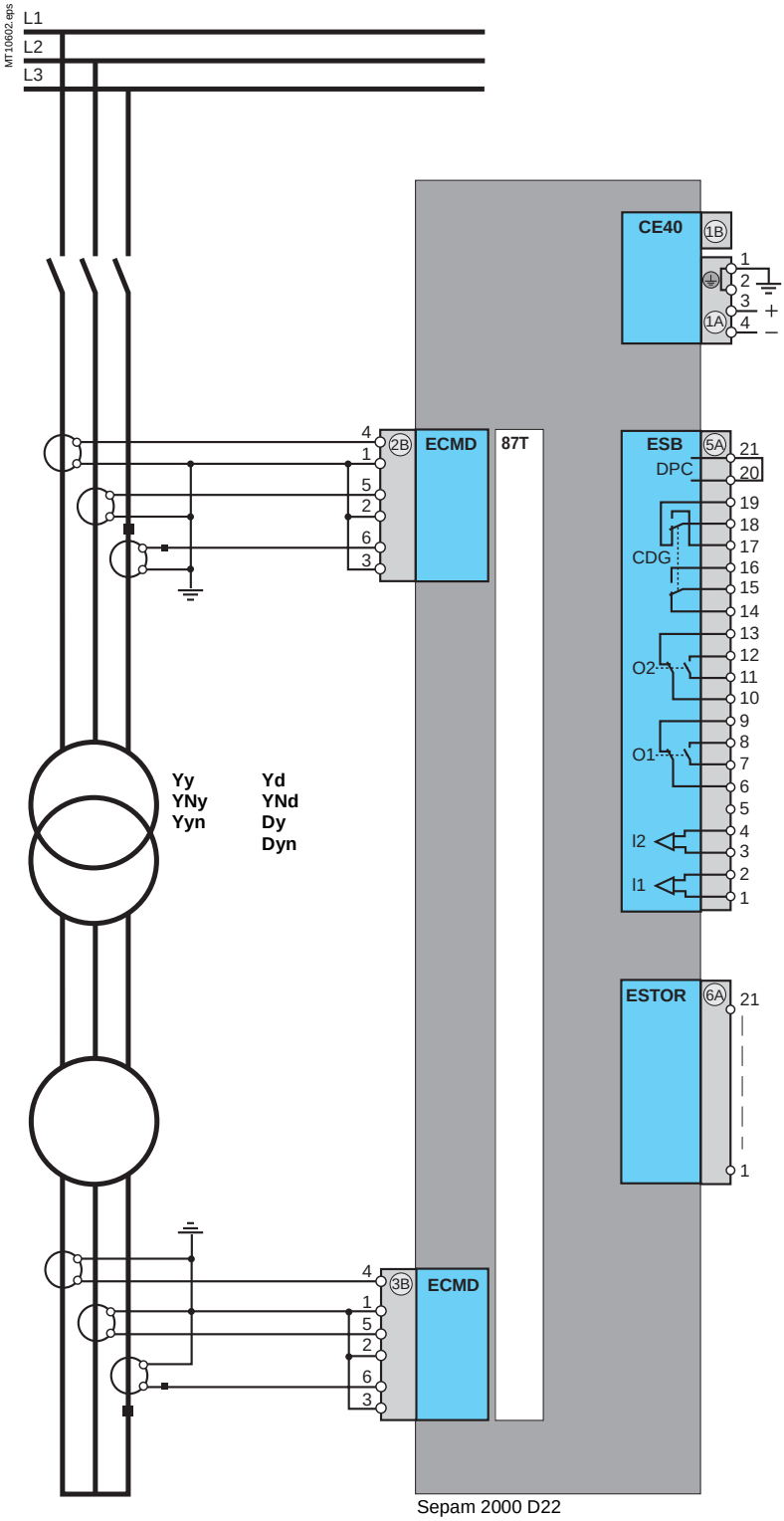

Connection of a 1 A current transformer via a CSH30 interposing ring CT.




*DPC: detection of plugged connectors*
*CDG: watchdog*

*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Generator-transformer unit

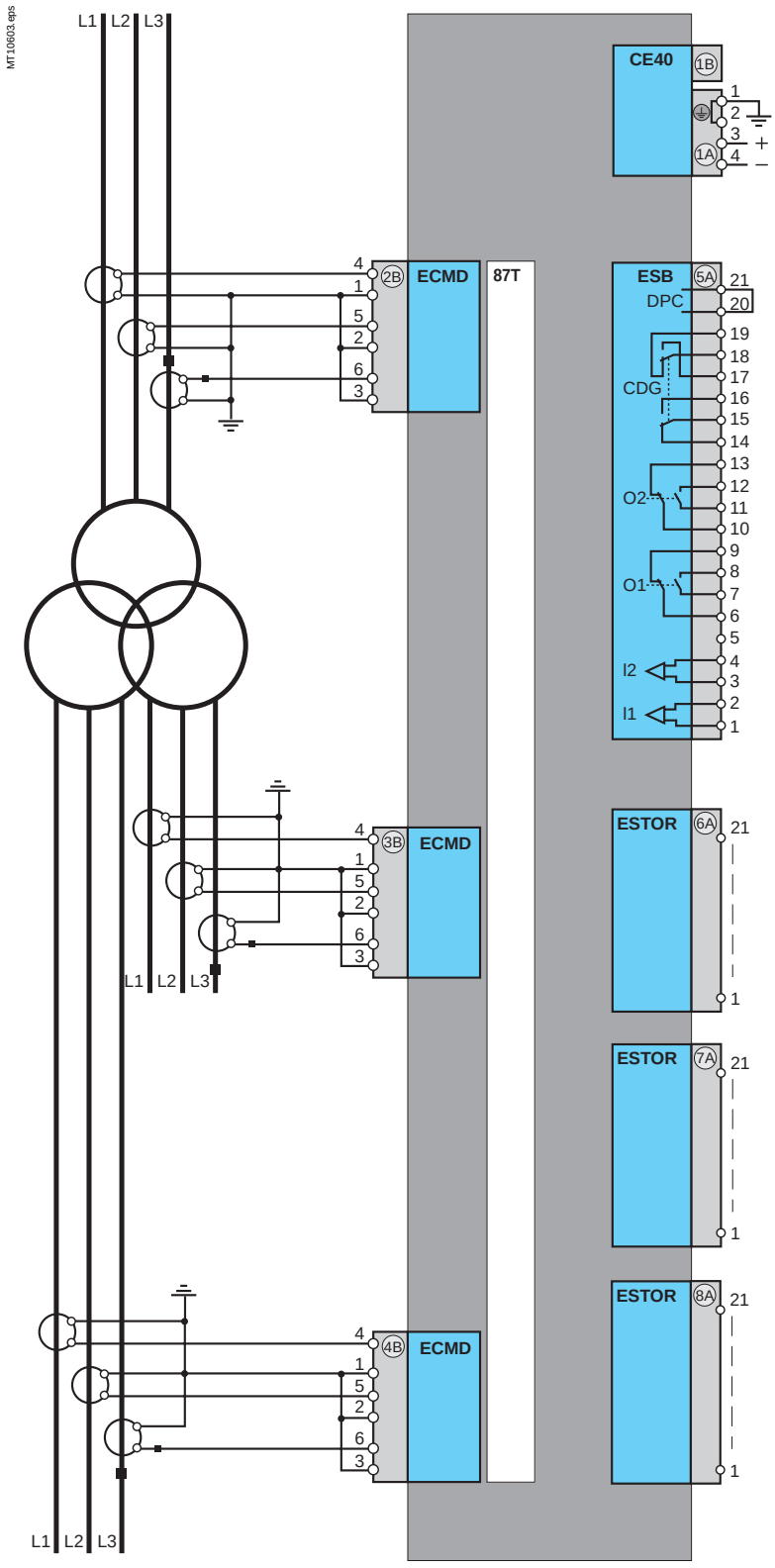



*DPC: detection of plugged connectors*
*CDG: watchdog*

*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Three-winding transformer

No neutral point CT is necessary for proper operation of the differential protection.

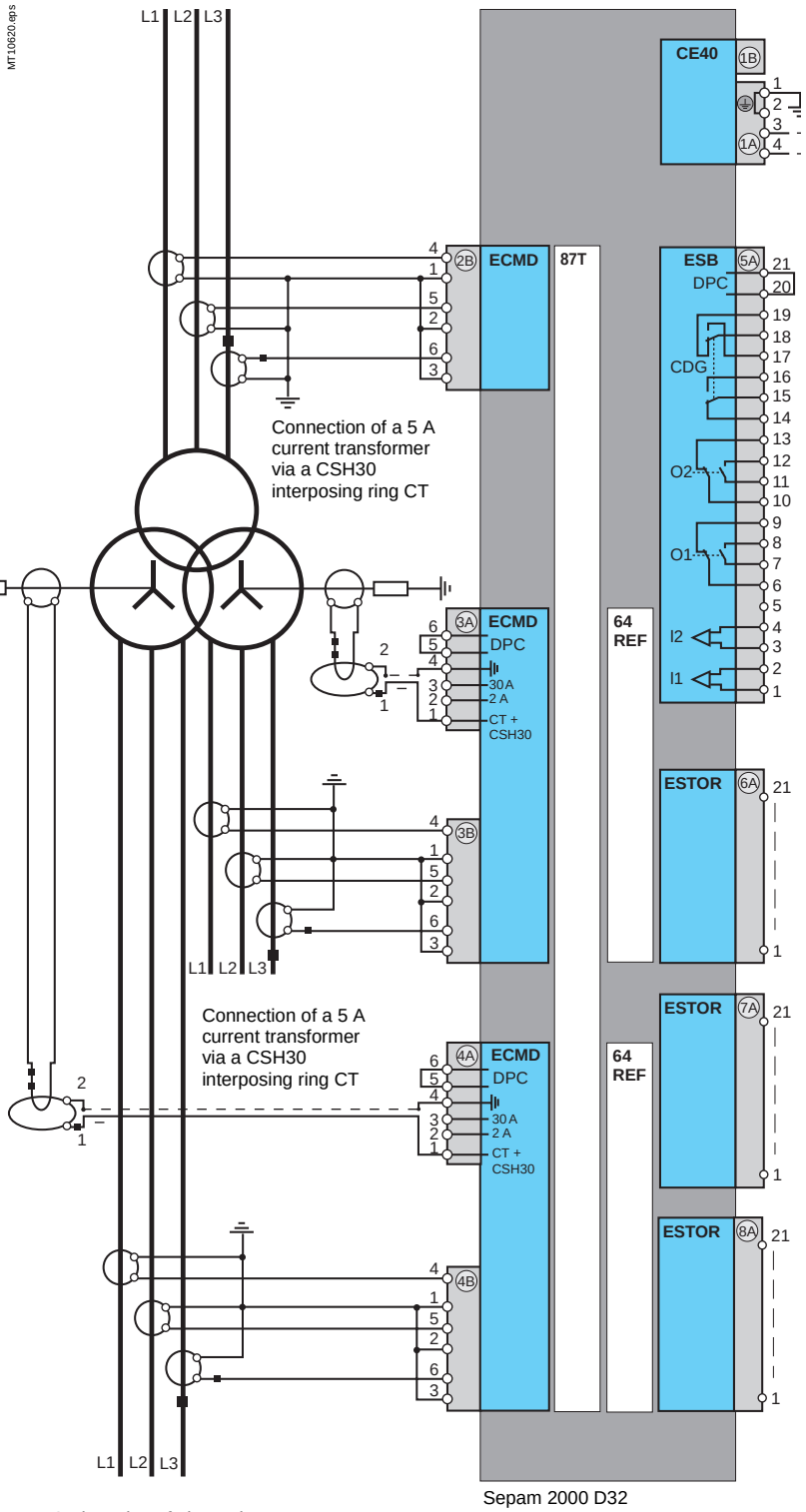



*DPC: detection of plugged connectors*
*CDG: watchdog*

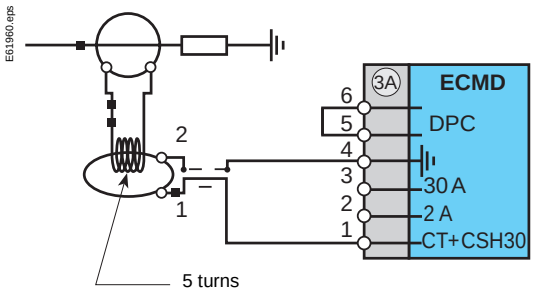
*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Three-winding transformer with 2 earthed neutral points

The neutral point current measurements are necessary for restricted earth fault protections.



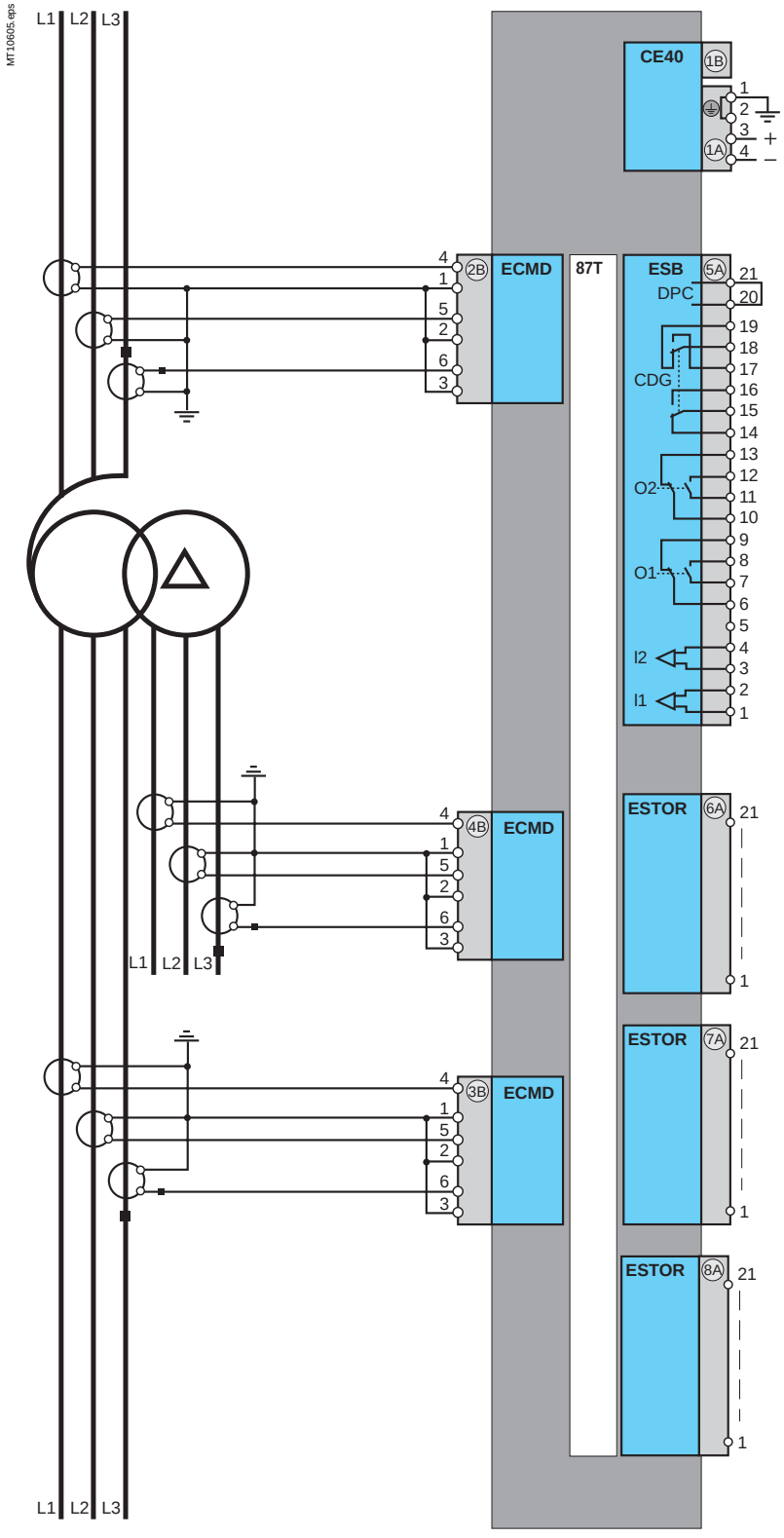

Connection of a 1 A current transformer via a CSH30 interposing ring CT.




*DPC: detection of plugged connectors*
*CDG: watchdog*

*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Three-winding auto-transformer

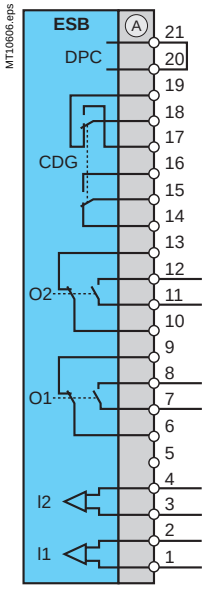



Sepam 2000 D32

*DPC: detection of plugged connectors*
*CDG: watchdog*

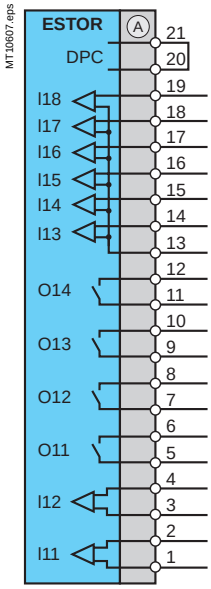
*Correspondence between primary and secondary connections (e.g. P1, S1)*

# Connection of logical inputs/outputs




## ESB board

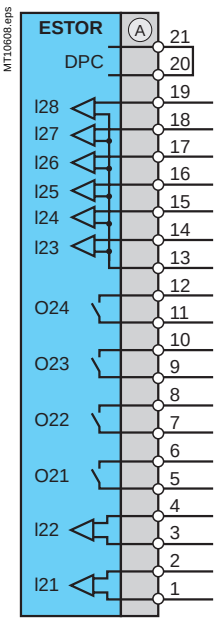
| Terminals | | Connected data | |
|---|---|---|---|
| | | D22 application | D32 application |
| 21<br>20 | DPC | detection of plugged connectors | detection of plugged connectors |
| 19<br>18<br>17<br>16<br>15<br>14 | CDG | watchdog | watchdog |
| 13<br>12<br>11<br>10 | O2 | secondary tripping | secondary tripping |
| 9<br>8<br>7<br>6 | O1 | primary tripping | primary tripping |
| 4<br>3 | I2 | auxiliary 1 tripping | external tripping |
| 2<br>1 | I1 | auxiliary 1 alarm | reserved |




## ESTOR 1 board

| Terminals | | Connected data | |
|---|---|---|---|
| | | D22 application | D32 application |
| 21<br>20 | DPC | detection of plugged connectors | detection of plugged connectors |
| 19 | I18 | Buchholz tripping | reserved |
| 18 | I17 | Buchholz alarm | reserved |
| 17 | I16 | thermostat tripping | reserved |
| 16 | I15 | thermostat alarm | reserved |
| 15 | I14 | auxiliary 2 tripping | reserved |
| 14 | I13 | auxiliary 2 alarm | reserved |
| 13 | | common | reserved |
| 12<br>11 | O14 | transformer differential or restricted earth fault indication | transformer differential or restricted earth fault indication |
| 10<br>9 | O13 | indication of winding 2 tripping | indication of winding 2 tripping |
| 8<br>7 | O12 | indication of winding 1 tripping | indication of winding 1 tripping |
| 6<br>5 | O11 | alarm: thermostat or Buchholz or auxiliary 1 or auxiliary 2 | reserved |
| 4<br>3 | I12 | remote control authorized | remote control authorized |
| 2<br>1 | I11 | reserved for communication synchronization | reserved for communication synchronization |

# Connection of logical inputs/outputs




## ESTOR 2 board (D32 application)

| Terminals | | Connected data |
|---|---|---|
| 21<br>20 | DPC | detection of plugged connectors |
| 19 | I28 | reserved |
| 18 | I27 | reserved |
| 17 | I26 | reserved |
| 16 | I25 | reserved |
| 15 | I24 | reserved |
| 14 | I23 | reserved |
| 13 | | reserved |
| 12<br>11 | O24 | reserved |
| 10<br>9 | O23 | reserved |
| 8<br>7 | O22 | indication of winding 3 tripping |
| 6<br>5 | O21 | winding 3 tripping |
| 4<br>3 | I22 | reserved |
| 2<br>1 | I21 | reserved |

# Notes

# Notes

# Ordering informations

## Sepam 2000

quantity

Sepam type

D22 ..... ☐

D32 ..... ☐

## Option

| | | |
|---|---|---|
| Communication ..... | without ..... | ☐ |
| ..... | Jbus/Modbus ..... | ☐ |
| Working language..... | French ..... | ☐ |
| ..... | English ..... | ☐ |
| ..... | Spanish ..... | ☐ |
| ..... | Italian ..... | ☐ |
| Auxiliary power supply ..... | 24/30 Vdc ..... | ☐ |
| ..... | 48/127 Vdc ..... | ☐ |
| ..... | 220/250 Vdc ..... | ☐ |

## Accessories

quantity

| | | |
|---|---|---|
| Pocket terminal..... | TSM2001 ..... | ☐ |
| Setting software with PC connexion kit ..... | SFT2801 + SFT2821 ..... | ☐ |
| Disturbance recording display software ..... | SFT2826 ..... | ☐ |
| Interposing ring CT for residual current input..... | CSH30 ..... | ☐ |
| Jbus/Modbus communication | | |
| ■ 9-pin sub-D connector box ..... | CCA619 ..... | ☐ |
| ■ Jbus/Modbus network connection box ..... | CCA609 ..... | ☐ |
| ■ cable (length: 3 m) with two 9-pin sub-D connectors ..... | CCA602 ..... | ☐ |
| ■ interfaces box RS485/RS232 ..... | ACE909-2 ..... | ☐ |

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